



# **Armed Forces College of Medicine (AFCM)**

## **Histology Department**



# **Erythropoiesis & Bone Marrow Structure**

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# Intended Learning Objectives (ILOs)



**By the end of this lecture the student should be able to:**

- **Describe** the microscopic structure of the bone marrow.
- **Describe** the cellular changes along the series of erythropoiesis.
- **Interpret** the changes in the reticulocyte count in the blood.

# Lecture Plan



- 1. Part 1 (3 min): Introduction to hematopoiesis**
- 2. Part 2 (40 min): Steps of erythropoiesis and bone marrow structure.**
- 3. Part 3 (3 min): Summary**
- 4. Lecture Quiz: (4 min)**

# Hematopoiesis



(Hemato= blood / Poiesis= making).

▪ **Definition:** The process by which blood elements are

▪ **Site:**

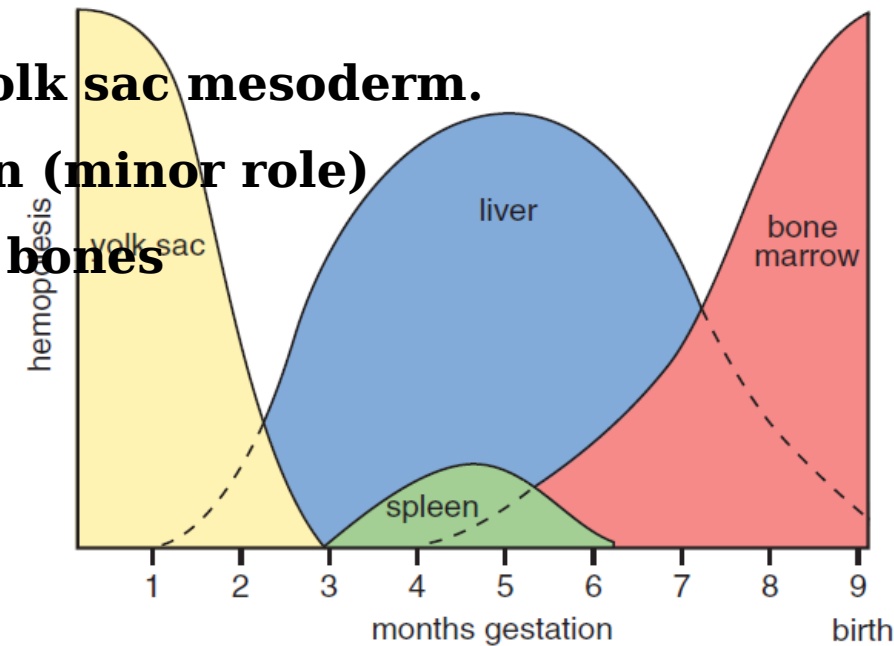
## ○ Prenatal hematopoiesis

- In the 1<sup>st</sup> trimester (starting from W3): in the yolk sac mesoderm.
- In the 2<sup>nd</sup> trimester: in liver (mainly) and spleen (minor role)
- In the 3<sup>rd</sup> trimester: in bone marrow of specific bones

## ○ Postnatal hematopoiesis:

- occurs in the **red** BM and lymphatic tissues

As the circulating blood cells have a relatively short life span and must be continuously replaced





# Hematopoiesis

**Stem cells**  
( BM )



**Progenitor cells**  
(CFU)



**Precursor cells**  
(=Blasts)



**Mature cell**  
(=Functioning cell)

**Self renewal**

**Multipotent (give all the blood cell types)**

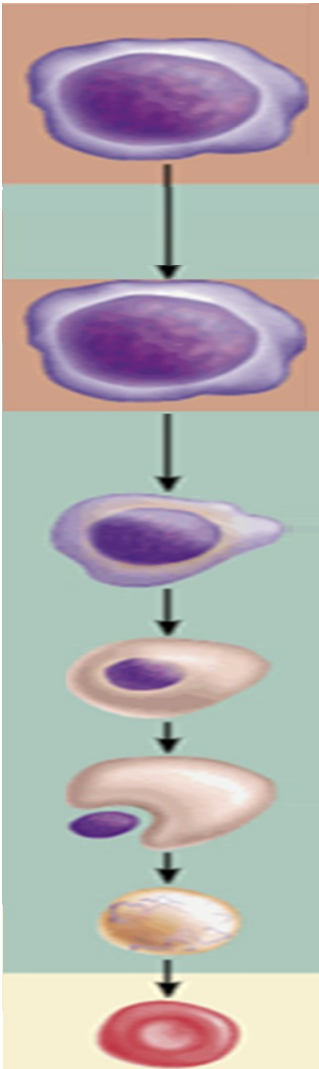
**Capable of asymmetric division**

Less self renewal

Less potential

**Committed to produce specific blood cells ( = Form colonies of only one cell type)**

**Gradually acquire the characteristic shape of the mature cells**

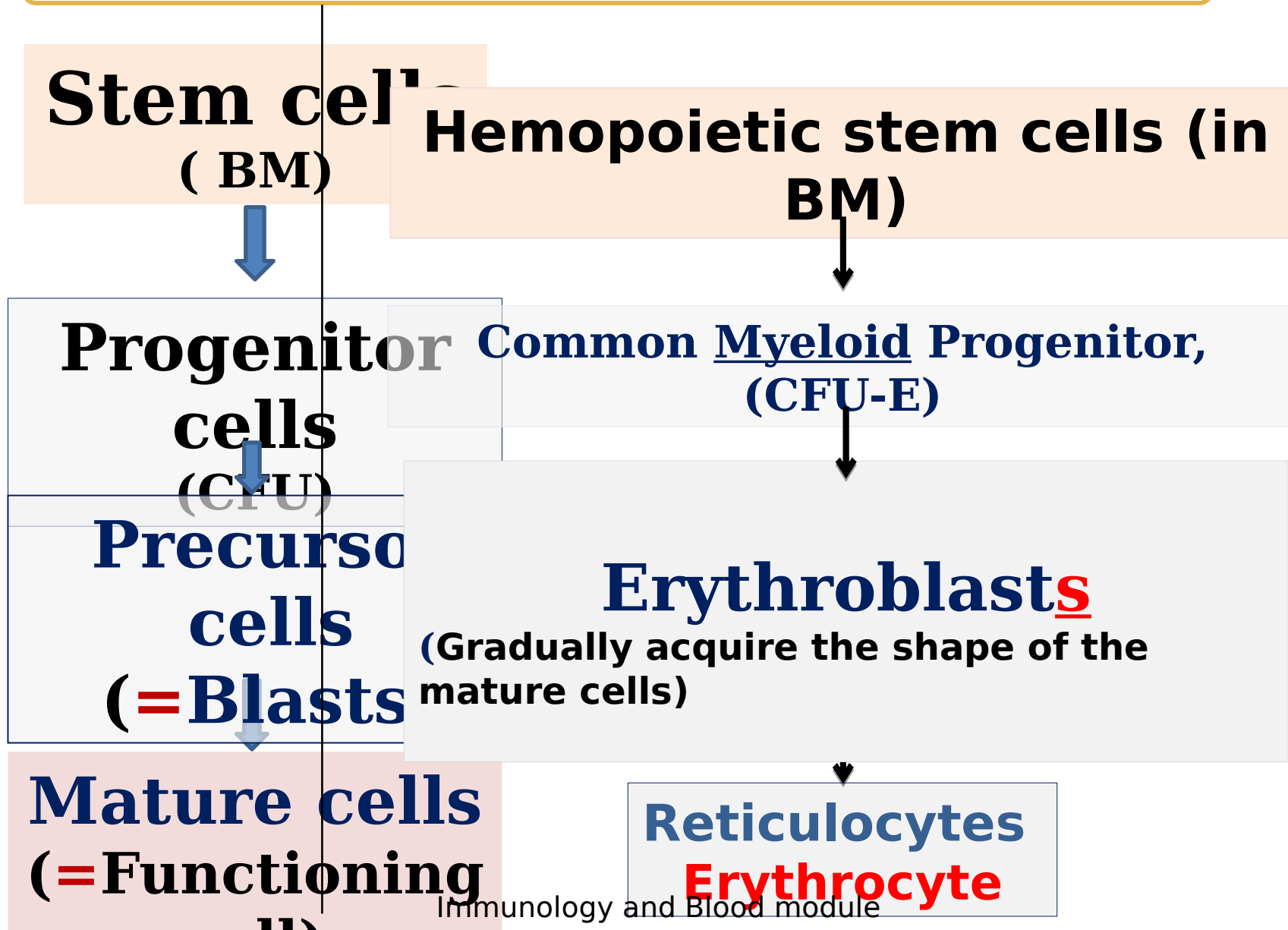


# **Erythropoiesis**

# Erythropoiesis



Erythrocyte





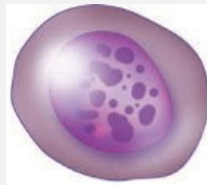


# Erythropoiesis

Common Myeloid Progenitor,  
(CFU-E)

Notice changes in:

- **Size**
- **Nucleus**
- **Cytoplasm**



**Pro-erythroblast**

(free ribosomes)

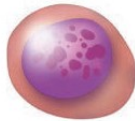
Basophilic Cytoplasm



**Basophilic Erythroblast** →

(free ribosomes)

Basophilic Cytoplasm



**Polychromatophylic erythroblast** →

(free ribosomes and Hb) (last mitosis)

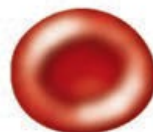
Basophilic & Acidophilic C.



**Normoblast**

dark nuclei. Then, it will eject the nucleus)

**Erythrocyte**

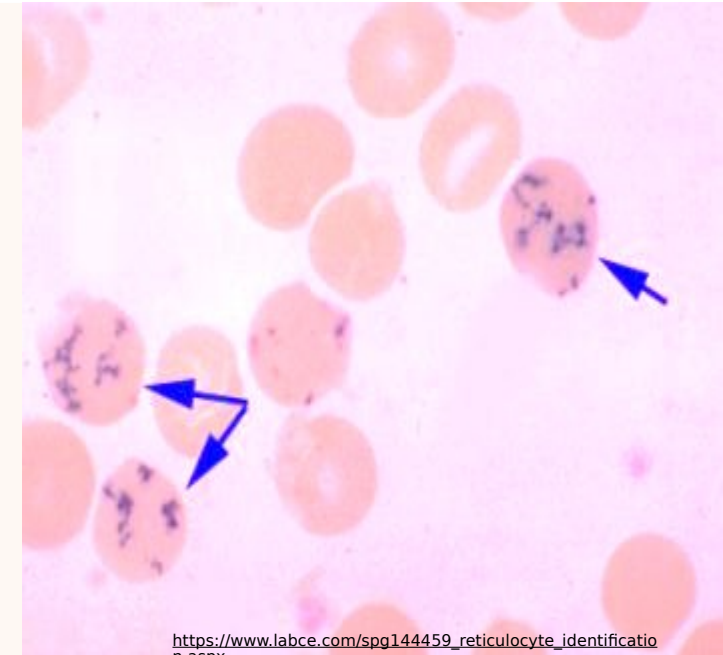


# Reticulocytes

## (Polychromatophylic erythrocytes)



- Immature cells, slightly larger than erythrocytes
- **Number:** **1-1.5%** of erythrocytes in the peripheral blood.
- **LM:** (**brilliant cresyl blue**)  
Show faintly stained basophilic network,
- **Fate:** because it retains few polyribosomes, soon loses its polyribosomes and becomes mature erythrocytes.
- **Clinical significance:** Increase (free ribosomal RNA) in **blood loss** (ex: chronic hemorrhagic anemia).



## The corrected reticulocyte count:

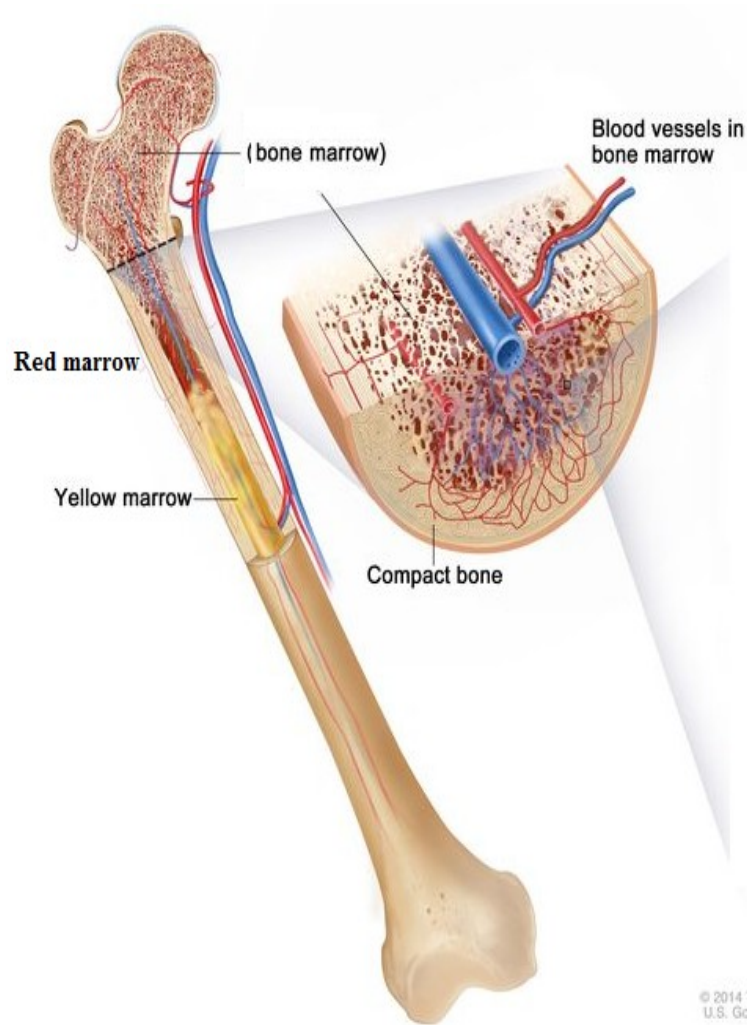
- **It** evaluates the degree of patient's BM response to the anemic stimulus.
- It is calculated as:

$$\frac{(\text{Patient's hematocrit}) \times (\text{reticulocyte count})}{\text{normal hematocrit (=45\%)}}$$

- The corrected reticulocyte count: <2% indicates **poor** BM response

>3% indicates **good** BM

response.



# Bone Marrow

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# Bone Marrow



## Structure:

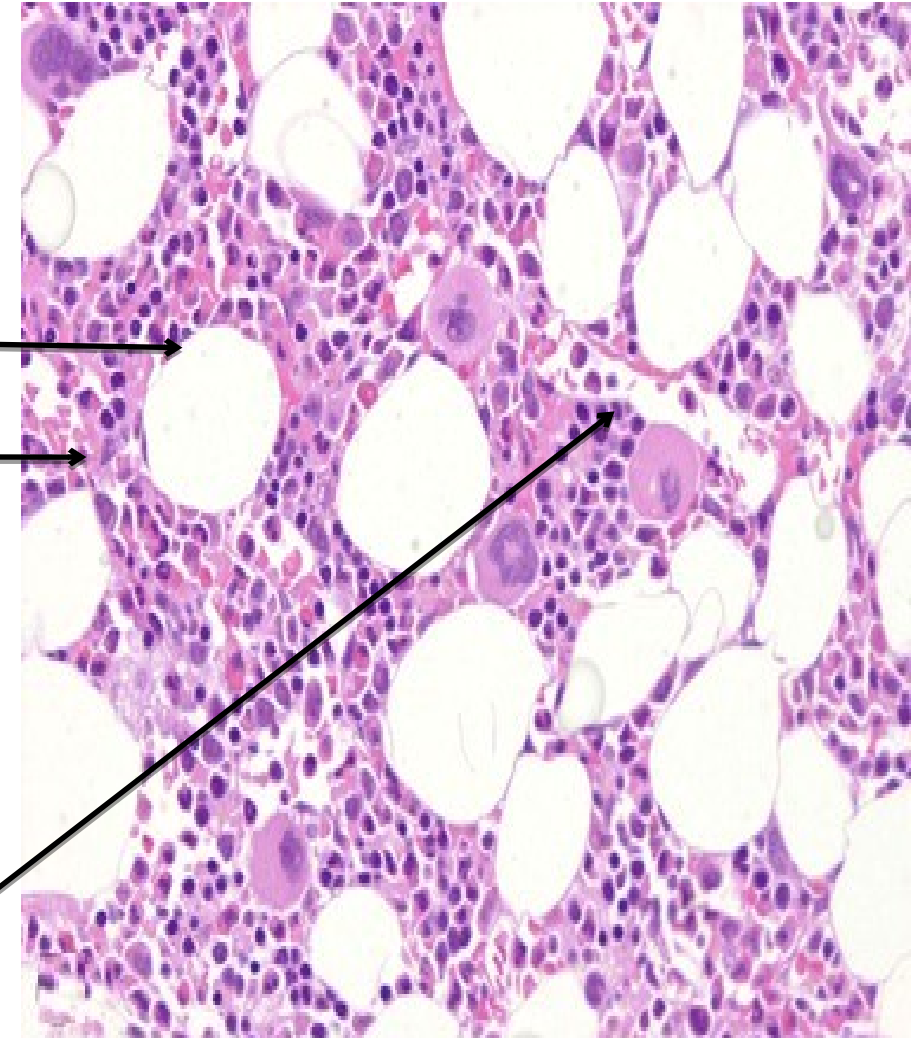
- 1- **Stroma:** formed of
- **Reticular** fibers, **collagen** fibers: for support.
  - **Stromal cells** (~~=Reticular cells~~): special fibroblasts
  - **Fat storing cells**

### (Hemopoietic cords)

- **Population of free developing cells** (erythroid, myeloid and megakaryocytic lineages)

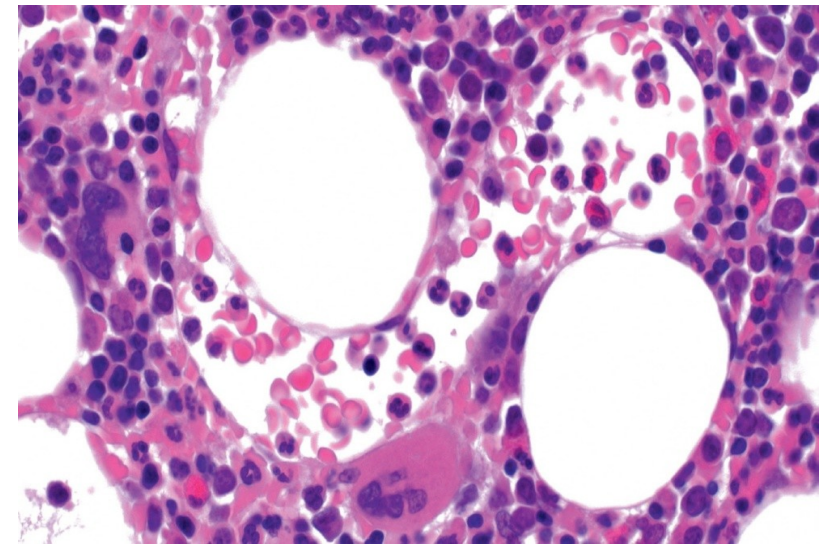
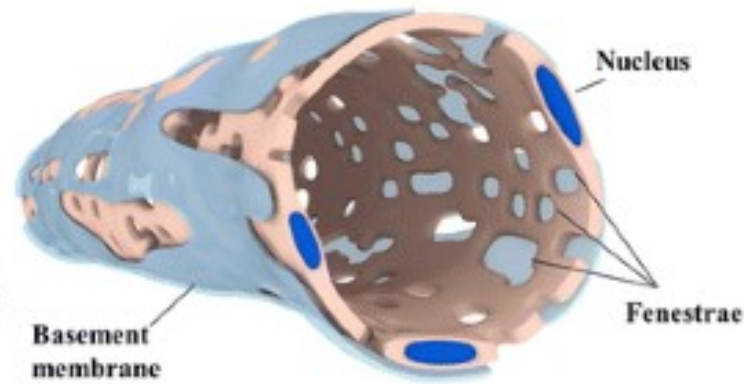
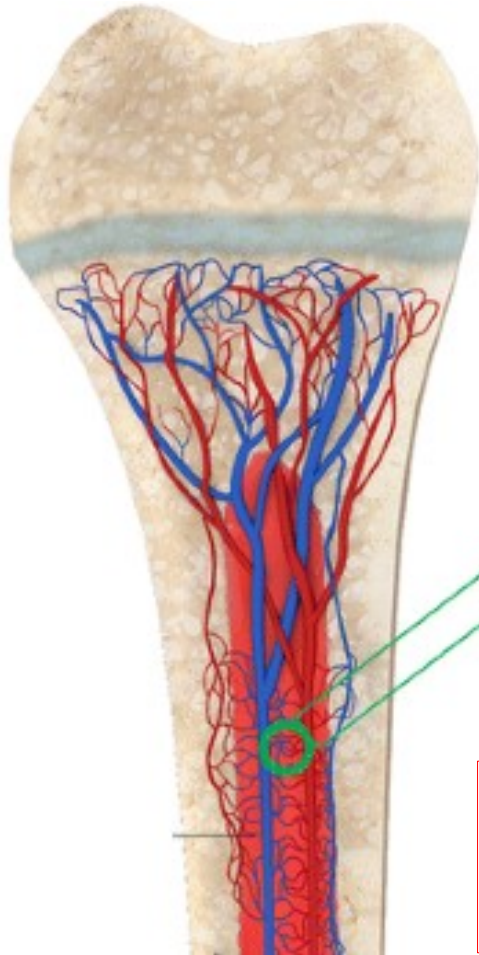
3-**Macrophages:** phagocytosis of old RBCs.  
They are ~~free~~ mobile cells (~~not fixed~~).

4-**Blood sinusoid:**



## BM Blood sinusoid:

- Thin wide irregular capillaries, formed of
  - 1- Fenestrated endothelial cells
  - 2- Discontinuous basement membrane



**Why  
Fenestrated ???**

**Through which newly differentiated blood cells and platelets enter the circulation**



# Bone Marrow

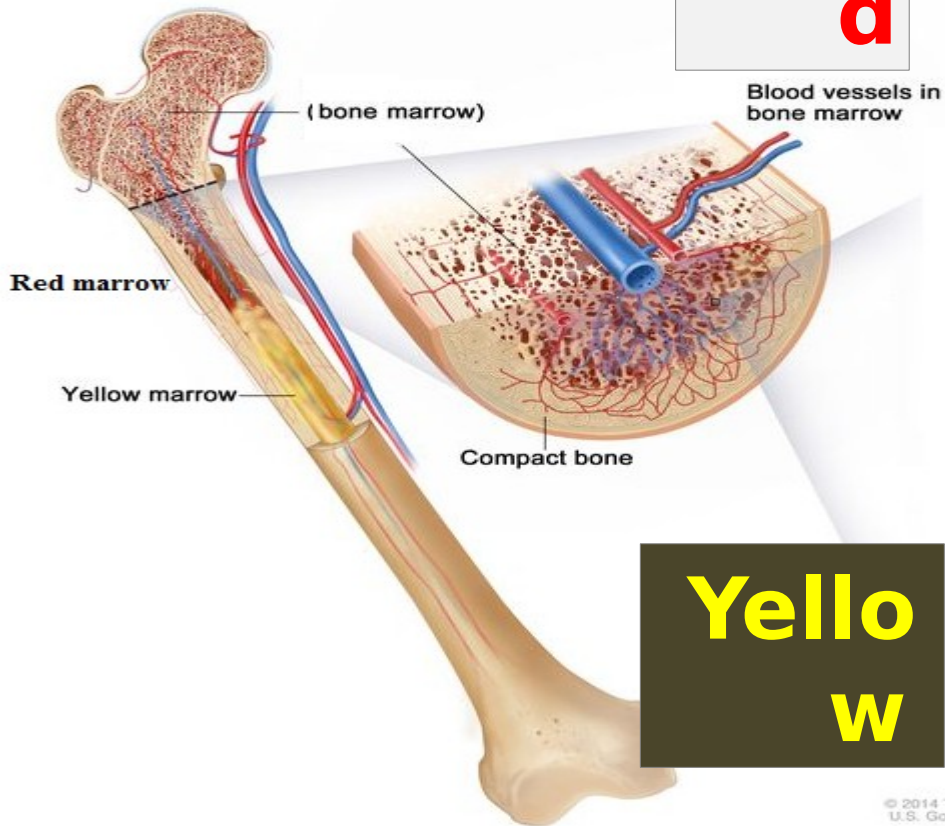
**2**  
**Types**

**2**  
**Ratios**

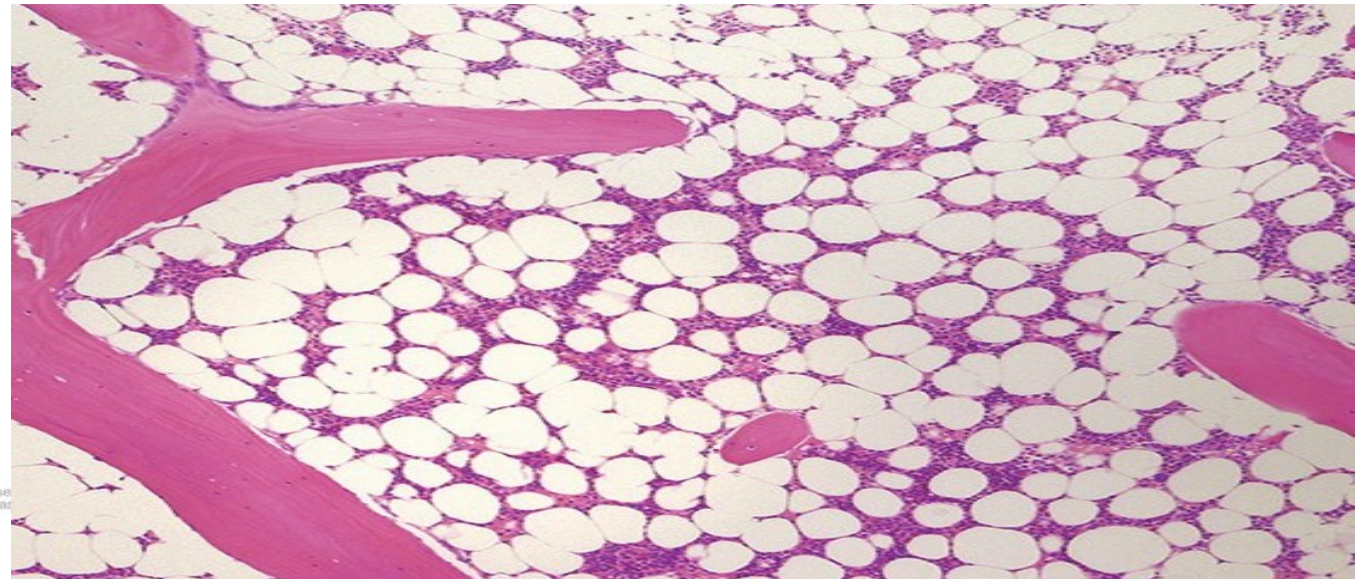
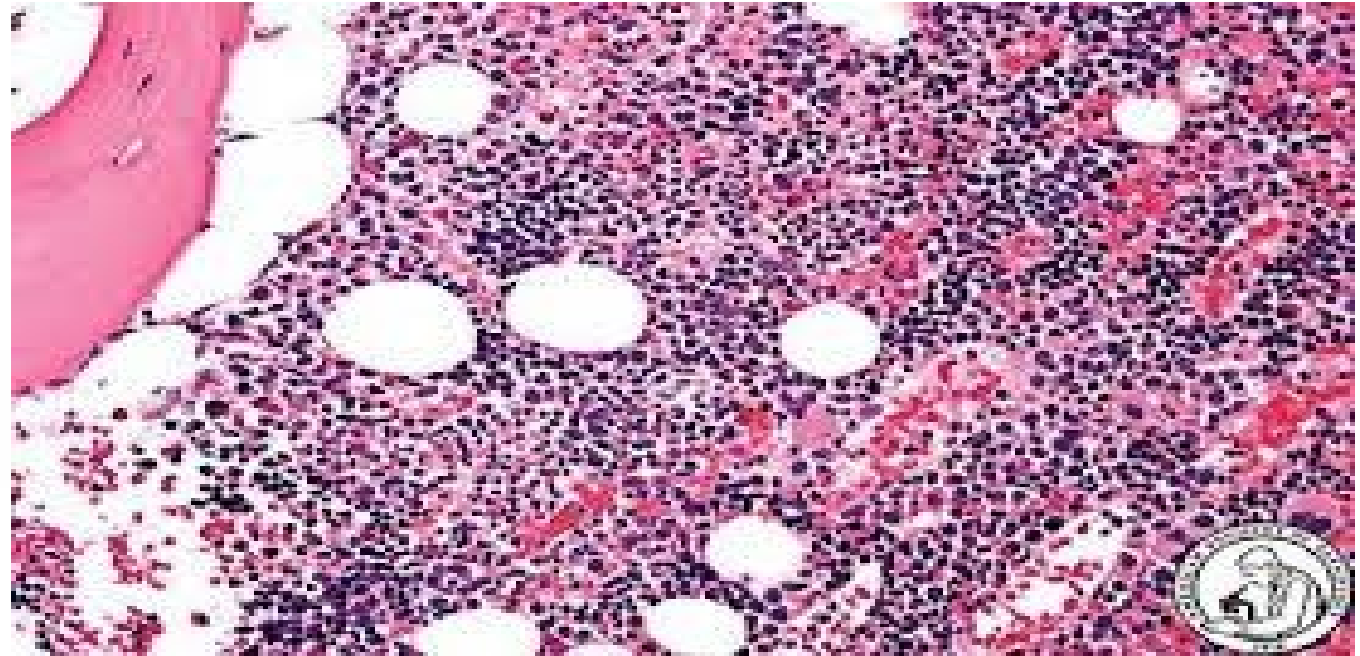
**BM Biopsy: most commonly from “iliac crest”**

# 2 Types

Red



Yellow



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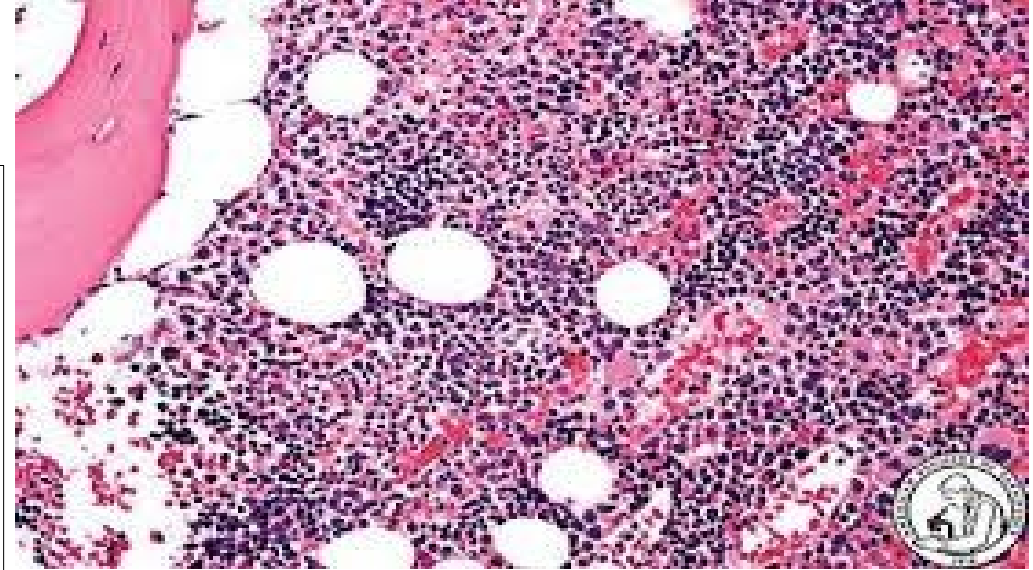


# Bone Marrow:



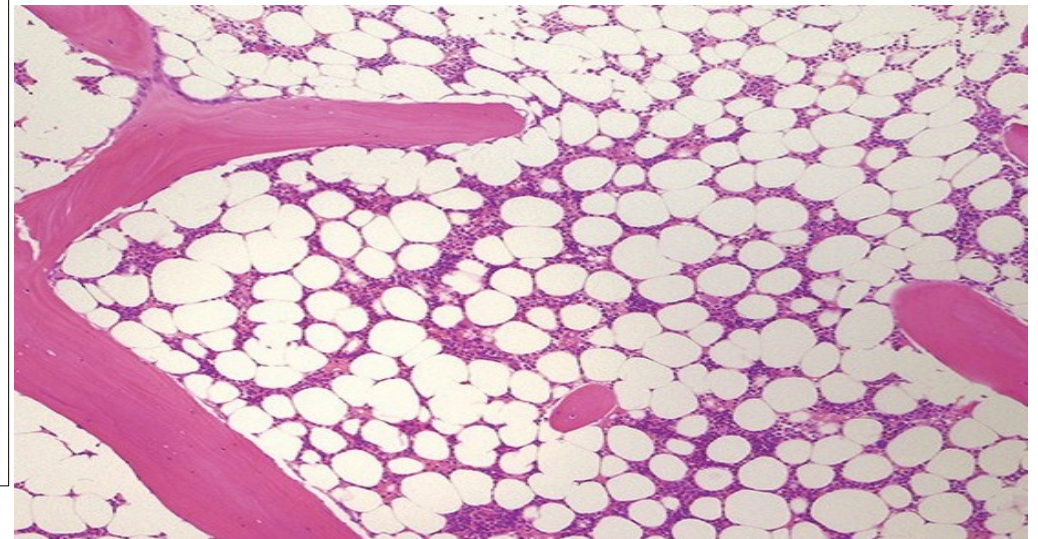
## 1- Red bone marrow:

- The site of hematopoiesis.
- Red color is due to abundance of blood & hemopoietic cells.



## 2- Yellow bone marrow:

- Inactive for hematopoiesis,
- Yellow color is due to abundance of fat cells

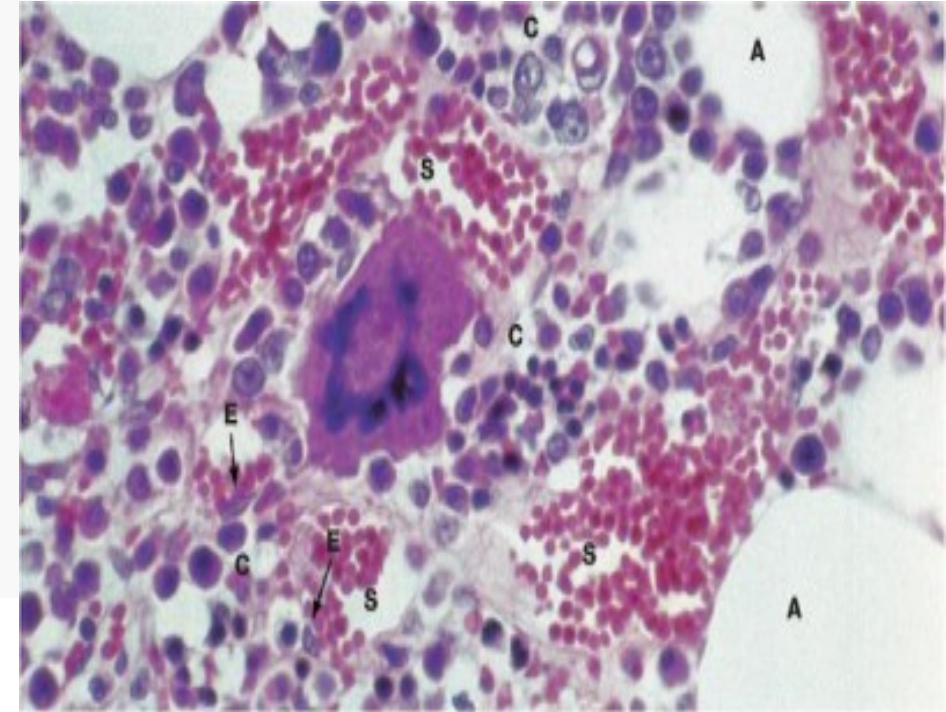


# Bone Marrow



## Sites of red BM:

- In Fetus: all long bones.
- In adult life, red BM is restricted to:
  - Epiphysis of long bones.
  - Some short bones
  - Irregular & flat bones: pelvis, ribs, sternum, bodies of vertebrae, bones of skull vault.



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**During growth, red BM is progressively replaced by yellow BM in most of long bones.**

**N.B.:**

**In times of increased need for erythrocytes (as in hemolytic anemia), yellow BM can change to red BM**

## 2

# Ratios

### 1. Haematopoietic-to-fat ratio = “BM cellularity”

- The ratio between hemopoietic cells to fat cells.
- It changes with age (decrease with age):
  - Newborn to 3 months 80-100%
  - 20-40 years 60-70%
  - 40-70 years 40-50%
- The normal level (adult) is evaluated by the following formula:  $(100 - \text{the age} \pm 10\%)$ .



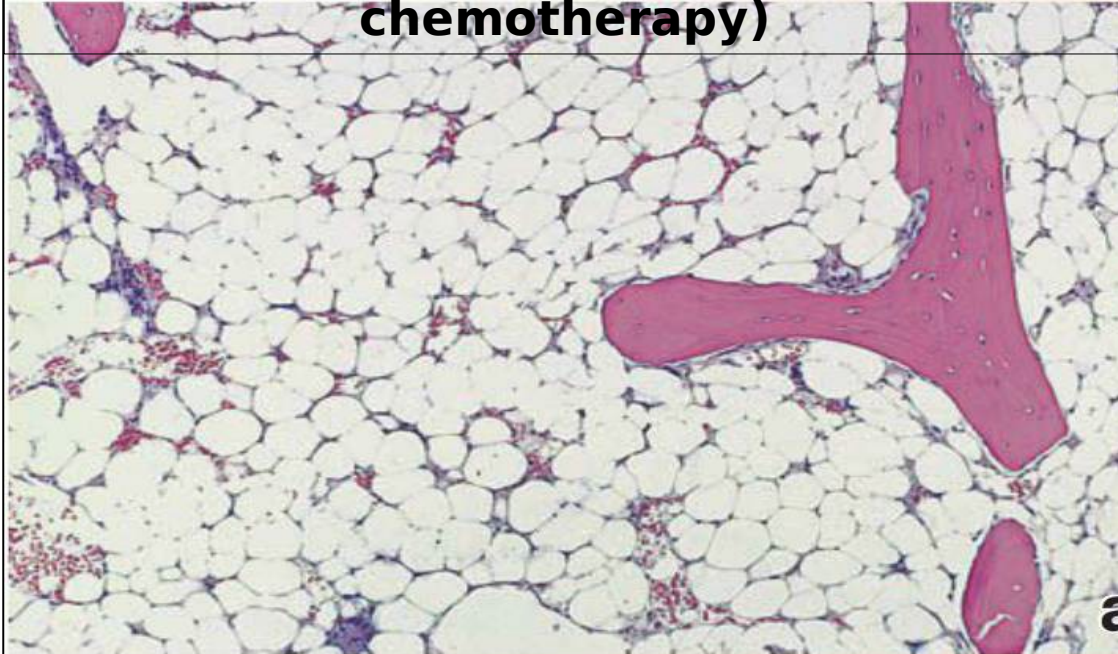
# Bone Marrow



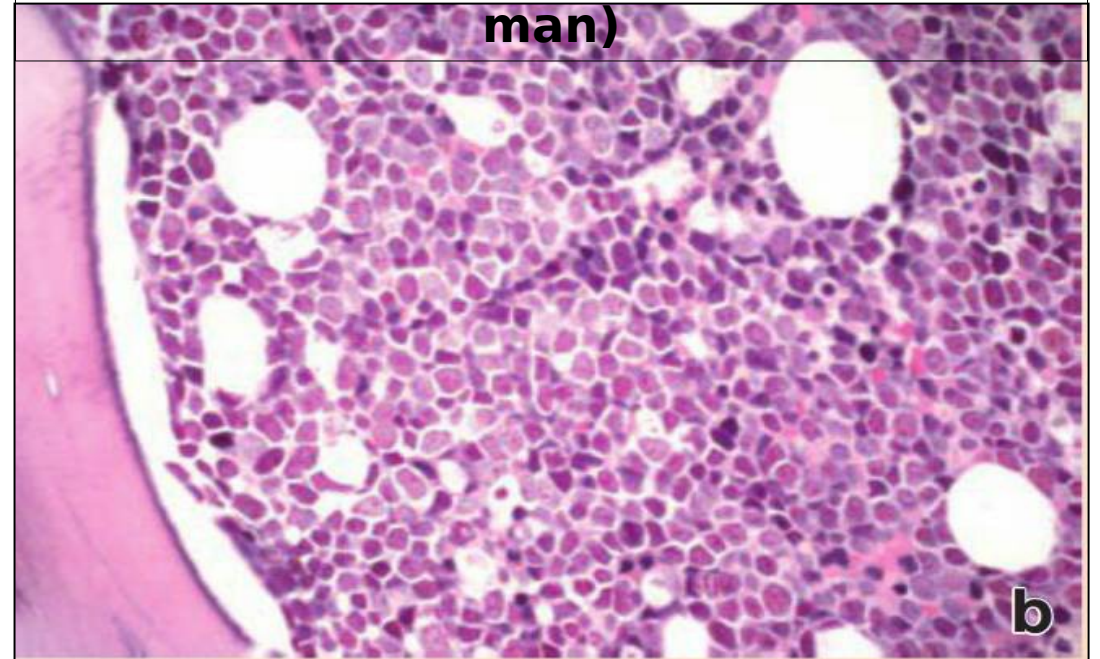
## Clinical correlation: “BM cellularity”

- Hypocellularity: aplastic anemia, chemotherapy
- Hypercellularity: polycythemia, leukemia “proliferation”

**Hypocellular BM** (Aplastic anemia, chemotherapy)



**Hypercellular BM** (Tumor in 50 yr old man)



# 2

## Ratios

### 2. Myloid-to-Erythroid ratio

- The ratio between myloid to erythroid precursors.
- Normally = 3:1

### Clinical correlation:

- Increased ratio: Chronic myloid leukemia
- Decreased ratio: erythroid hyperplasia

# Quiz

A 35-year-old woman undergoes routine blood screening as part of a pre-employment physical. The screening demonstrates a mild anemia characterized by small cells with relative pallor compared to normal erythrocytes. Deficiency of which of the following would be most likely to have caused this patient's anemia?

- a) Iron
- b) Folate
- c) Vitamin-B12
- d) Vitamin-C

# Compare between yellow bone marrow and red bone marrow

	Yellow bone marrow	Red bone marrow
Site		
Structure		
Function		



- **Mention the cells in the erythropoietic series that can undergo self renewal**
- **Describe the reticulocytes and assess the value of counting them.**

## **SUGGESTED TEXTBOOKS**



- 1. Junqueira`s Basic Histology; Text and Atlas. 14<sup>th</sup> edition 2018.**
- 2. Histology A Text and Atlas: Michael H. Ross and Wojciech Pawlina, 7<sup>th</sup> edition, 2016.**

Thank  
you

